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Application Note

USING THE MC68000 AND THE MC6845 FOR A COLOR GRAPHICS SYSTEM

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Probably the slowest link in most computerized control systems is the display of information for human interpretation. The commonly used black and white monitor can display an adequate amount of information in most cases.

In applications where a large amount of information must be displayed in the same screen area, a color graphics system can easily provide this information by using a wide range of contrasting colors. Until recently the high cost of sophisticated components and color monitors required to generate and display color information has probably been the main prohibitive factor in development of these systems.

Recently the cost of components and color monitors has moderated to the point that using a color graphics system offers a viable solution to information display, ranging from the video games market to complex control systems.

A state-of-the-art color graphics system using the MC68000 16-bit microprocessor (MPU) with an economical MC6845 CRT controller (CRTC) is described in this application note. Hardware improvement is evident in data movement occurring in 16-bit words and multiply and divide commands while software compatibilities are greatly enhanced through the use of a processor that executes instructions which can operate on 8-, 16-, or 32-bit operands.

The general approach to a color graphics system is straightforward and almost identical to a black and white graphics system. A typical black and white graphics system is shown in Figure 1. The MPU has two responsibilities to the graphics system: first, to initially program the CRTC, and second, to transfer data to the display RAM.

Once the clock circuitry is running, the CRTC is initialized and the address lines to the dislay RAM begin incrementing sequentially. As this occurs, the appropriate data from the display RAM is loaded into the shift register and then gated out serially by the dot clock input to the shift register. The display monitor then interprets the data as either turning a particular pixel on or off.

A color graphics system (Figure 2) uses the same principle as the black and white system except that it has to control three color guns (red, green, and blue) instead of just one. Therefore, there is an increase in the amount of hardware involved, but not in complexity. The software becomes more

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involved due to the fact that more information is being handled and displayed. The basic display system works on the principle that three bits (one for each color) controls each pixel instead of just one as in a black and white system. If two guns are on, the resulting color is a combination of the two. If all guns are on, white is the result. With this configuration a total of eight colors, including black and white, are available. Since the three bits needed to control a pixel do not fit into an eight-bit byte evenly, the unused bits could be used to obtain more colors or some other function. In addition, color systems usually require a separate sync input.

The versatility of the internal architecture of the MC68000 (Figure 3) enhances the effectiveness of the color graphics system. Besides containing a 32-bit program counter yielding 16 megabytes of direct addressing range, the MC68000 also contains eight 32-bit data registers (D0-D7) and seven 32-bit address registers (A0-A6). The eight data registers are used for byte (8-bit), word (16-bit), and long word (32-bit) data operations. The seven address registers and the stack pointer may be used for word and long word address operations. In addition, all address and data registers may be used as index registers.

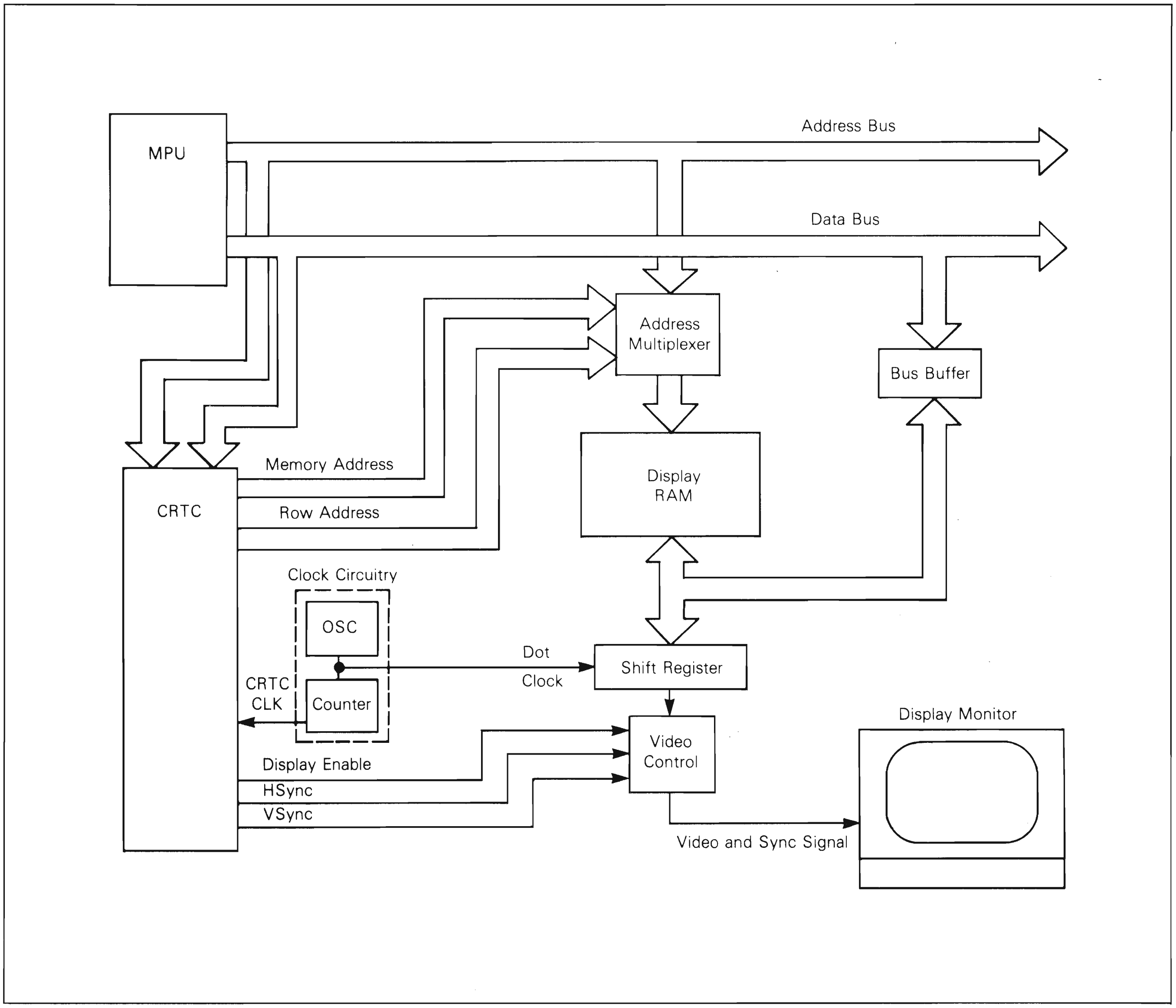


Figure 1. Black and White Graphics System — Block Diagram

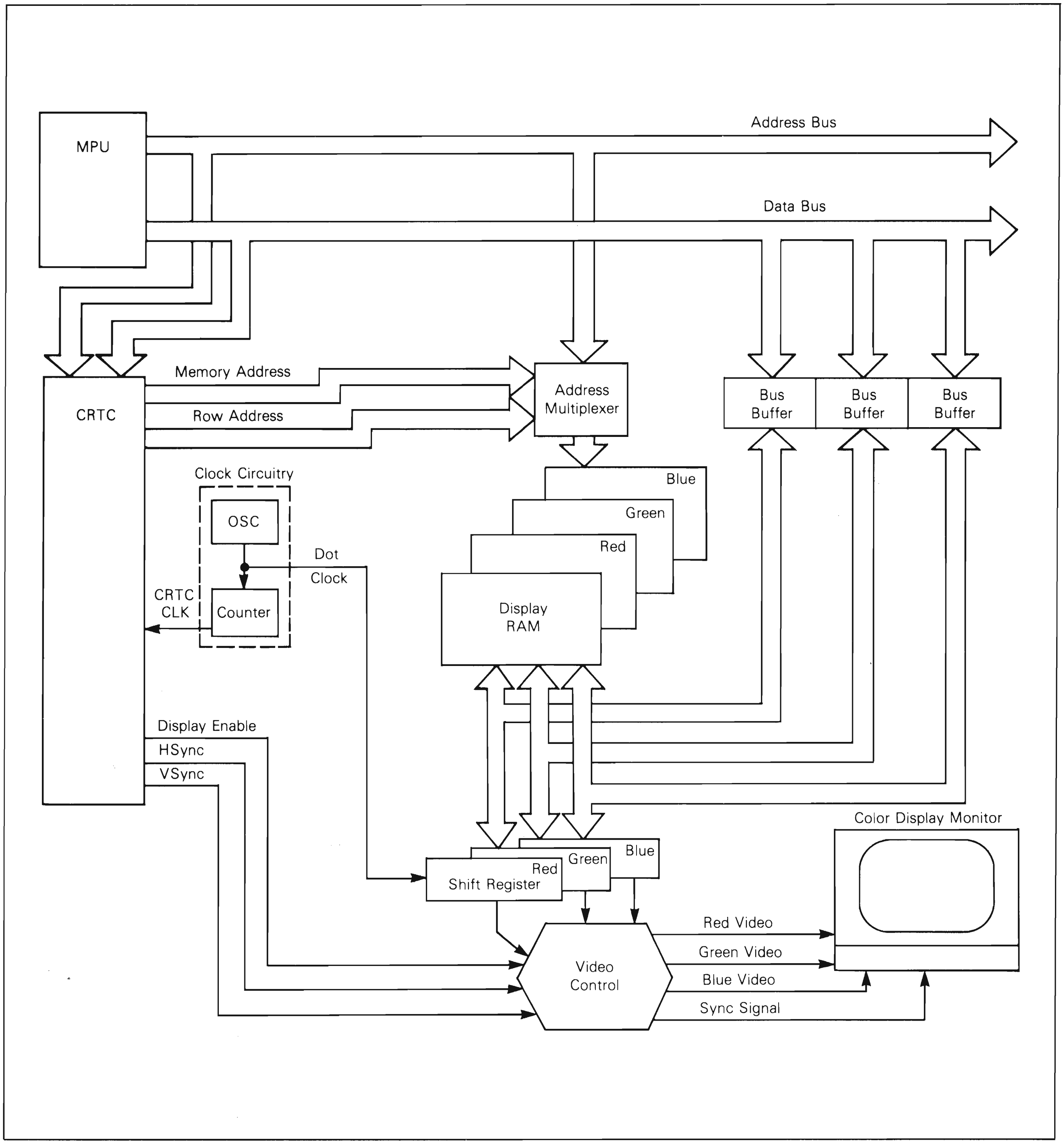


Figure 2. Color Graphics System — Block Diagram

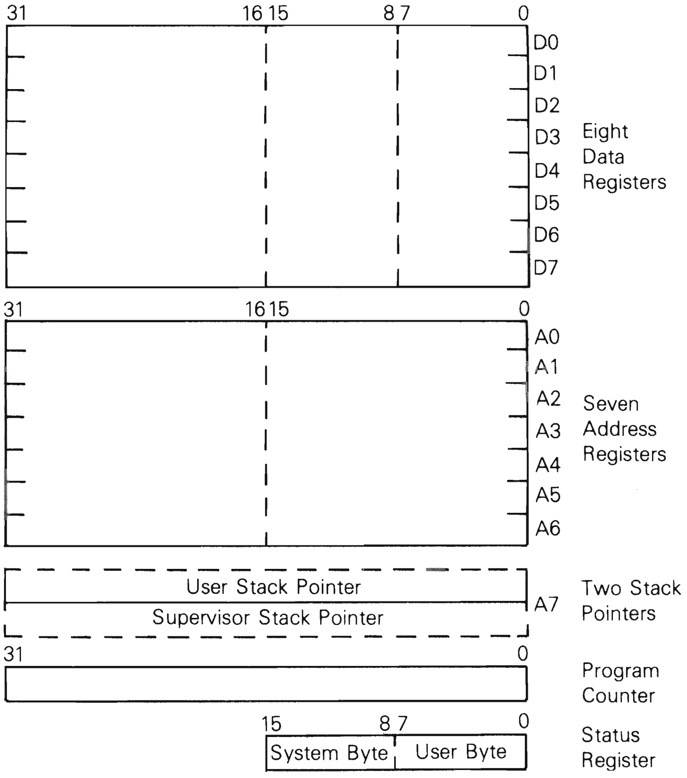


Figure 3. MC68000 Programming Model

SYSTEM HARDWARE DESCRIPTION AND FEATURES

This graphics system consists of two boards: a CPU board and a video board. The CPU board contains the processor, scratch-pad RAM, stack RAM, the program EPROM, and a terminal interface. The video board contains the CRTC, display RAM, multiplexers and buffers, parallel-to-serial shift registers, and the D/A drivers for the color display monitor.

An MC68000 Design Module (MEX68000KDM) is used as the CPU board. The resources available on the MC68000 Design Module allow more design time to be spent on the unique features of the system. The major portions of the system provided by the Design Module are the MPU (MC68000), the address decoding for the EPROM, a terminal interface, and all the software functions provided by the resident monitor (MACSbug). Included in the MACSbug is a transparent down-load feature which allows the system to communicate through the terminal to another system. The other system can provide the access to the floppy disks needed by this color graphics system for saving a full screen of data at a time.

The video board (Figure 4) contains more of the unique hardware features of the color graphics system. The video board can be separated into seven areas: the clock circuit, CRT controller, the DTACK circuit, the bus multiplexers and buffers, the display RAM, the shift registers, and the D/A converter drivers.

The clock circuit generates the five timing signals used throughout the video board; they are: a dot clock, a CRTC clock, a 2X dot clock, a shift register load, and a $\phi 2$ signal. The dot clock is used to drive the serial shift registers. The CRTC clock is used to drive the CRTC. The 2X dot clock and the shift register load are gated together to generate the parallel load (PLOAD) and chip select (PCS) signals for the shift registers and display RAM, respectively. The $\phi 2$ signal is also used to control accesses to the display RAM. A timing diagram of these signals is shown in Figure 5.

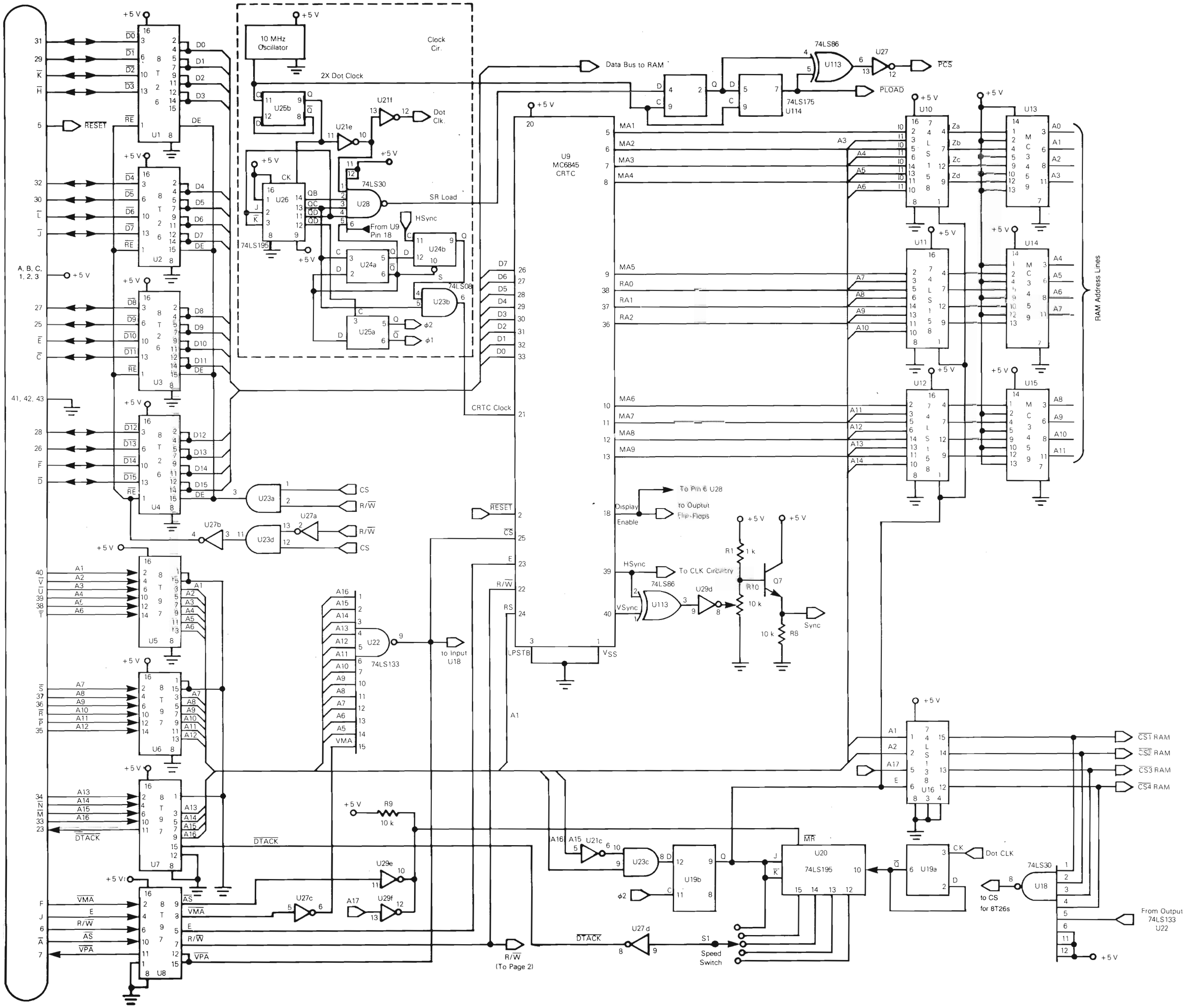


Figure 4. Color Graphics System Schematic (Sheet 1 of 3)

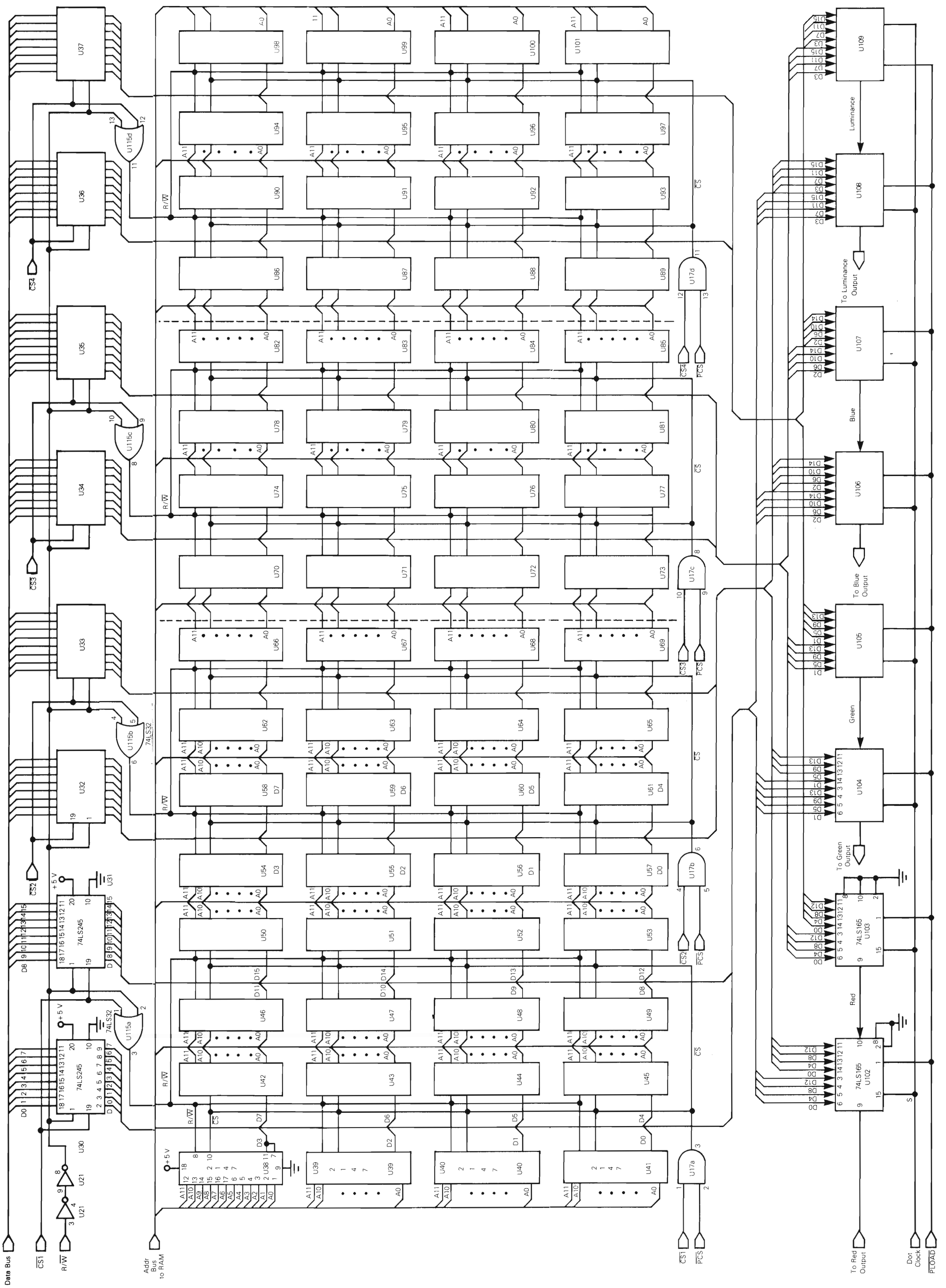
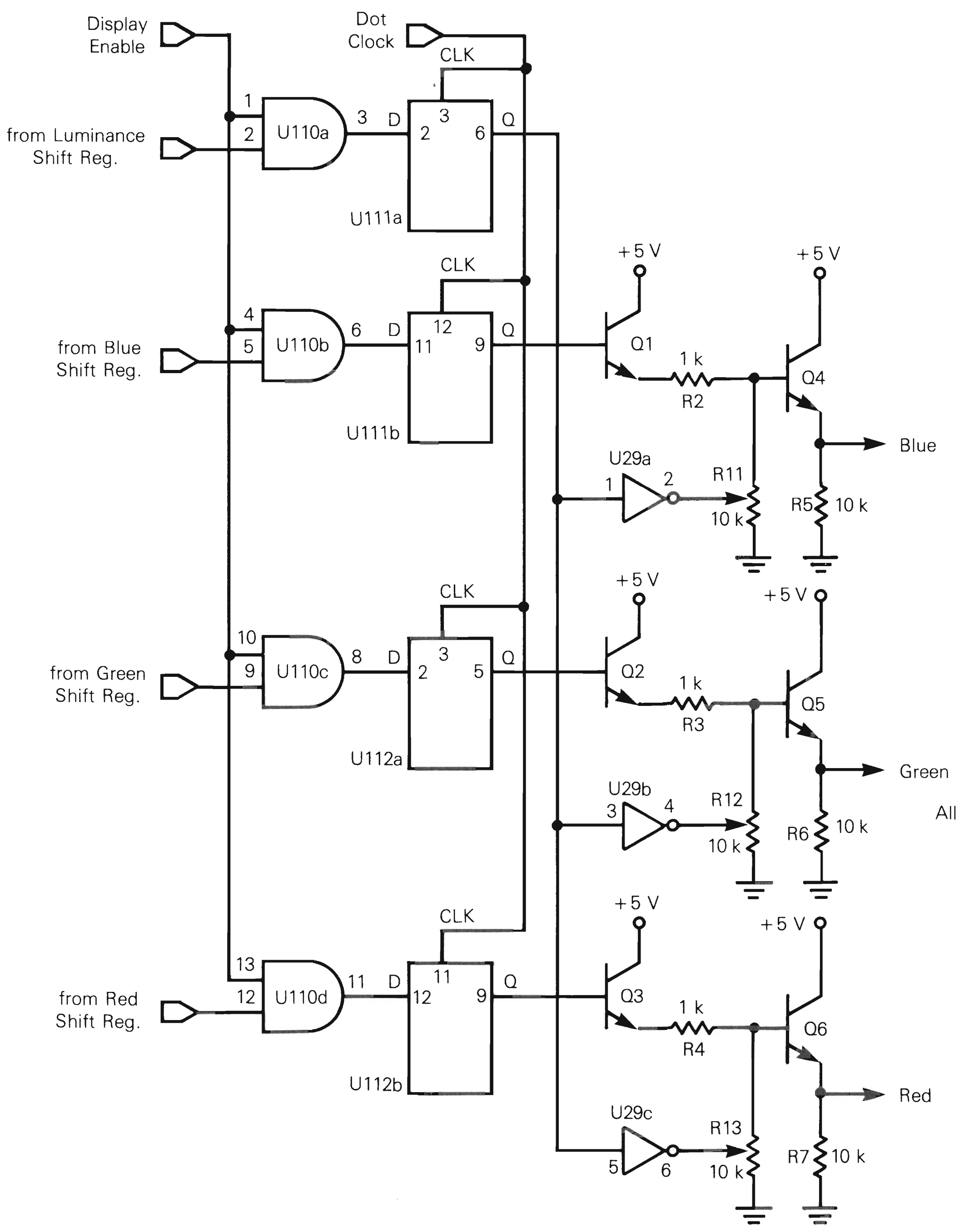


Figure 4. Color Graphics System Schematic (Sheet 2 of 3)



Parts List

U1-4	MC6880A/MC8T26A		
U5-8	MC6887/MC8T97		
U9	MC6845		
U10-U12	SN74LS158		
U13-15	MC3459		
U16	SN74LS138		
U17, 23, 110	SN74LS08		
U18, 28	SN74LS30		
U19, 24, 25, 111, 112	SN74LS74		
U20	SN74LS195		
U21, 27	SN74LS04		
U22	SN74LS133		
U23	SN74LS08		
U24, 25	SN74L'S74		
U26	SN74LS195		
U27	SN74LS04		
U28	SN74LS30		
U29	SN74LS05		
U30-U37	SN74LS245	10 MHz Oscillator	
U38-U101	MCM2147	Q1-Q3	2N3904
U102-U109	SN74LS165	Q4-Q7	2N5336
U110	SN74LS08	R1-R4	1 kΩ
U111, U112	SN74LS74	R5-R9	10 kΩ
U113	SN74LS86	R10-R13 (Variable)	10 kΩ
U114	SN74LS175		
U115	SN74LS32	S1 5-Position Switch	

All D Flip-Flops Configured for Power-Up Reset as Shown
(Where Possible)

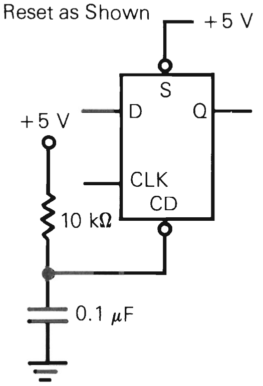


Figure 4. Color Graphics System Schematic (Sheet 3 of 3)

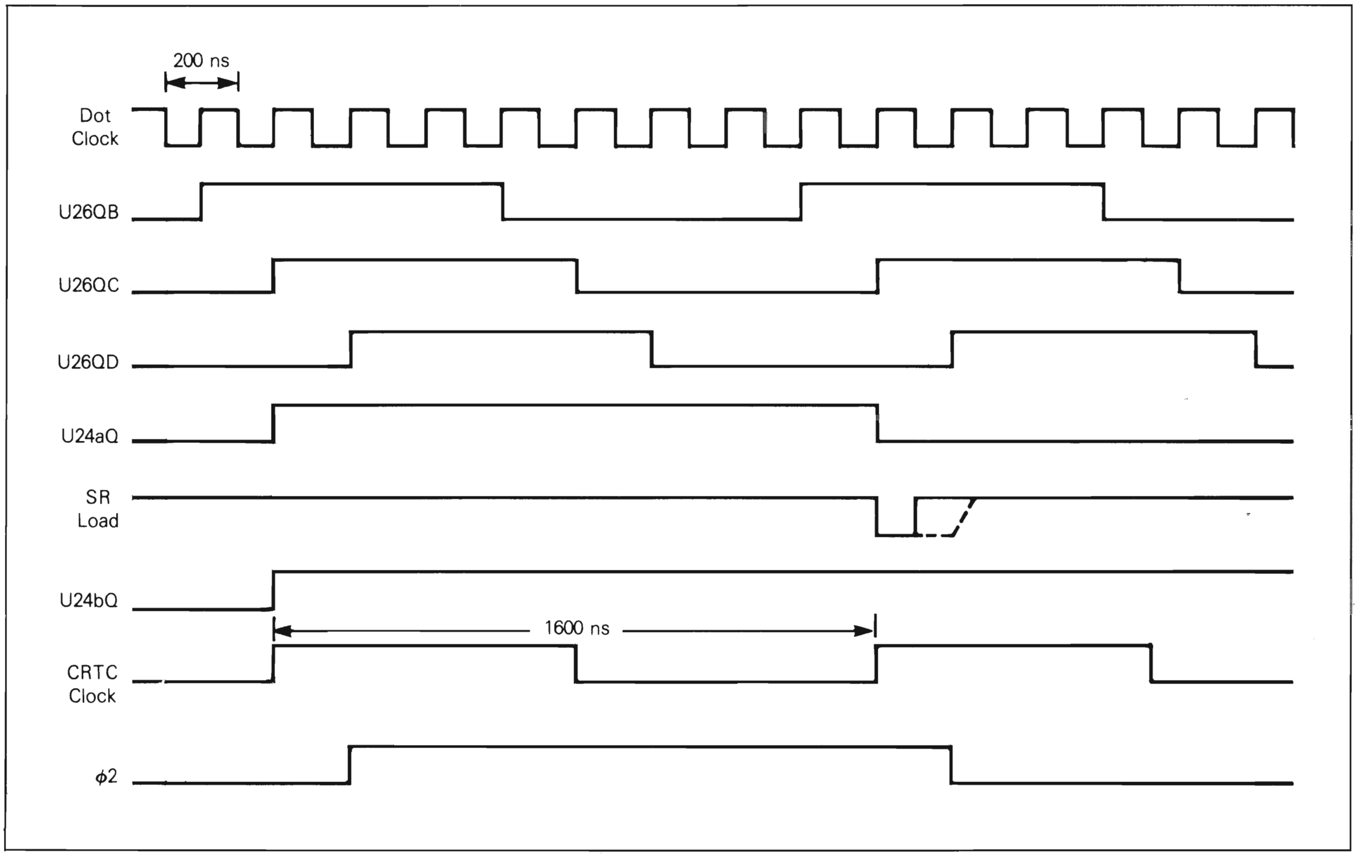


Figure 5. Clock Circuitry Timing Signals

The MC6845 CRT controller (CRTC) is a programmable controller used to prepare the information in the display RAM for use by a video display monitor. The CRTC generates the signals required to provide data at the appropriate times. Since the length and period between these signals varies from system to system, the CRTC is designed to be programmed by an MPU. In this system the internal registers are accessible synchronously through hex ($) address locations $1FFFD and $1FFFF. After programming, the CRTC provides the addresses, horizontal and vertical sync signals, and the display enable signal to the display system. The addresses, output by the CRTC in conjunction with the parallel chip select ($\overline{PCS}$) signal, are responsible for the correct data getting to the serial shift registers at the correct time. The horizontal and vertical sync signals, after being "exclusively ORed," generate the sync signal required by the color display monitor. The display enable (DE) signal is gated (U28) into either the clock circuitry to inhibit the parallel load and $\overline{PCS}$ signals or is gated (ANDed at U110, if a low represents black on the screen) with the data stream to keep the guns in the CRT off during vertical and horizontal retrace. In some cases, DE must be delayed due to specific requirements of the CRT being used. A one-shot on the output of the DE pin is usually more than adequate for providing the delay.

The $\overline{DTACK}$ circuitry is used to return an asynchronous data transfer acknowledge ($\overline{DTACK}$) signal to the MC68000 from a synchronous device (the display RAM). The $\phi 2$ signal from the clock circuitry in conjunction with address lines A15 and A16 develop the $\overline{DTACK}$ response required by the MC68000. When the display RAM address is between $10000-$17FFF, the $\overline{DTACK}$ signal is returned in 400 nanosecond increments from zero up to 1600 nanoseconds after the enabling signal goes out to the multiplexers. This time is selected by the RAM speed switch, S1. Returning $\overline{DTACK}$ to the processor is the asynchronous access method by which the MC68000 can access external devices (RAM, ROM, and peripherals). This access method was chosen over the synchronous access method used to address the CRTC because it is faster and, since this is a highly repetitive operation, any time saved here will be significant in the overall speed of the system. The synchronous access method is used to access the CRTC since the CRTC is only initialized once and this method uses fewer components.

The multiplexers and buffers are used to feed the various control signals to the rest of the system. Multiplexers U10, U11, and U12 determine which address bus will access the display RAM. When the control signal is high, the MC68000 has access to the RAM and when low, the CRTC has access. Buffers U13, U14, and U15 are used to drive the large number of devices on the address bus. Data buffers U30-U37 are used to isolate the four banks of RAM from each other. Buffers are also used for almost all the signals coming onto the video board. These board buffers interface with the modified EXORciser bus which the Design Module uses. This bus has only sixteen address lines coming from the Design Module, so address line A17 must be run separately to keep the display RAM from being accessed at the same time MACSbug or the controller program is accessed (addresses $20000 and $22000).

The display RAM is organized into four banks (red, green, blue, and luminance). However, the address lines are configured so that consecutive words are located in consecutive banks of RAM. This was done to allow the programmer to visualize accessing one 16-bit wide bank at a time instead of accessing red, green, blue, and luminance banks all at the same time. The memories used are 4K×1 static RAMs (MCM2147) which simplify some of the chip select circuitry. Dynamic RAMs could be used and should definitely be considered in a production system since they lower the hardware cost as well as power consumption. They were omitted in this application to simplify the system configuration. It should be noted that the CRTC keeps incrementing its address lines during horizontal and vertical retrace to keep the dynamic RAM refreshed. The speed of the static memories is not critical due to the presence of the speed selection switch explained earlier. As far as the CRTC and the serial shift registers are concerned, the memory looks like one 4K×64-bit bank of RAM.

Shift registers U102-U109 consist of eight 8-bit, parallel-load, serial shift registers. They are configured to look like four 16-bit shift registers, one for each of the color guns and one for luminance. With the RAM and shift registers configured in this fashion, the RAM is accessed only 25 percent of the time. This means that the RAM has four times the amount of setup time and slower RAM can be used. The dot clock then clocks the data out to be gated with display enable.

Conversion from digital to analog voltages in this system is needed because a luminance bit is used to obtain more colors than are possible with the three guns digitally. The luminance bit is used to indicate half luminance when set and full luminance when clear. When all guns are off, the screen is black and the state of the luminance bit has no effect. Since the color display monitor uses an analog input on each gun, any number of colors may be obtained if the supporting hardware is provided. The D/A conversion used in this system was done to save space. A cleaner method would be to use special D/A converters and special line drivers for this function.

SOFTWARE DESCRIPTION AND CONSIDERATIONS

The software included to exercise this system consists of five basic commands:

CM — Clear Memory
BX — Box Draw
Q8 — Random Line
ED — Edit
BA}— Provides the capability of saving (BA) a screen on
SH} floppy disk and calling (SH) it back.

The clear memory (CM) command clears the screen. The box drawing (BX) command draws continuously concentric boxes which close in on each other. This gives the effect of running up a hallway. The random line (Q8) drawing command picks random points and connects them together until they form a multisided polygon and then it continues to repeat that shape, all the while collapsing in on itself and changing colors. A scaling function has been implemented to keep the figure occupying a major portion of the screen. The edit (ED) command allows the user to draw figures on the screen using the cursor controls on the terminal and allows a choice of colors. The BA command is used to store a screen full of data on floppy disk while the SH command is used to call it from the floppy disk and display it on the screen.

Each of the routines which write to the display RAM use the basic data layout for every pixel on the screen. Each pixel is controlled by four bits. Each bit corresponds to either luminance, blue, green, or red, as shown in Figure 6.

MSB LSB

	Luminance	Blue	Green	Red
Bits	3	2	1	0
	7	6	5	4
	11	10	9	8
	15	14	13	12

Figure 6. Pixel Control Bit — Layout

A memory map for this application is given in Figure 7. A listing of the software is given at the end of this application note.

The resolution of the display in this application is 256×256 pixels. The density could be doubled in both directions to 512×512 by quadrupling the memory. This can be easily done if dynamic RAM is used since 4K×1 and 16K×1 dynamic RAM can be arranged in the same basic configurations. As space was one of the design criteria in this application, some of the more straightforward approaches were not taken.

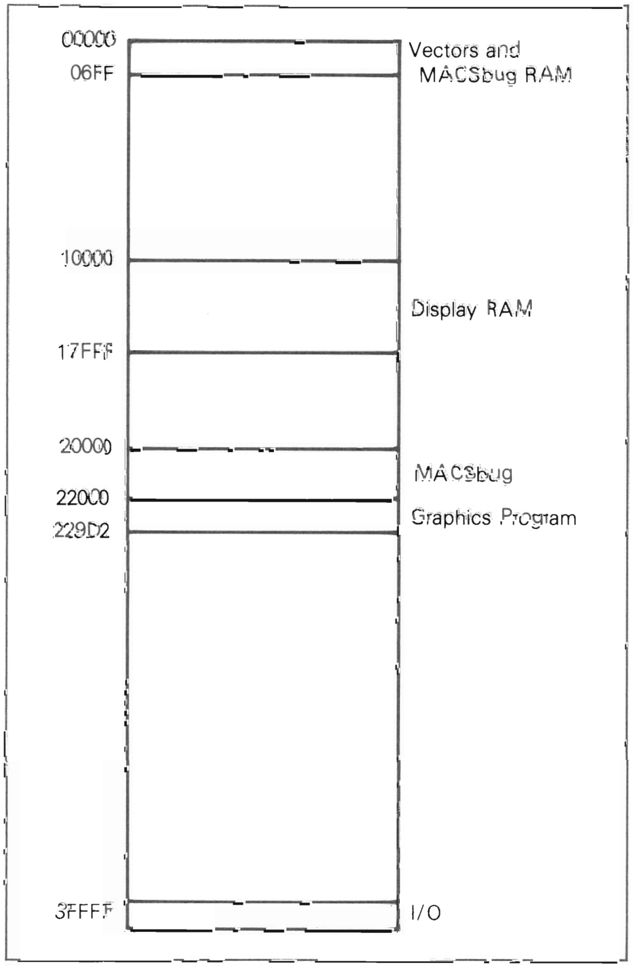


Figure 7. Memory Map

Thanks to Don Voss of Motorola Microsystems for his suggestions on the hardware and his splendid job on the software.

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SETUP4.S  MC68000 ASM REV= 1.0F- COPYRIGHT BY MOTOROLA 1978     PAGE  1

  10         00000000      ORG $0000
  20                       *
  30                       *
  40                       *
  50         000200F6     MACSBUG EQU $200F6
  60         00021BC2     OUTPUT2 EQU $21BC2
  70         00021F18     FIXBUF EQU $21F18
  80         000200EE     MSG EQU $200EE
  90         00001000     X1 EQU $1000
 100         00001001     Y1 EQU $1001
 110         00001002     X2 EQU $1002
 120         00001003     Y2 EQU $1003
 130         00001010     COLOR EQU $1010
 140         00001011     NCOLOR EQU $1011
 150         00001012     OCOLOR EQU $1012
 160         00001014     NUMPT EQU $1014
 170         00001016     SCALE EQU $1016
 180         00001018     RANADD EQU $1018
 190         00001080     ARRAY EQU $1080
 200         00001100     TABLECH EQU $1100
 210         00001800     CMDTAB EQU $1800
 220                      *
 230                      *
 240 000000 20780578      SETUP MOVE.L $578,A0
 250 000004 227C00001800   MOVE.L #CMDTAB,A1
 260 00000A 21C90578       MOVE.L A1,$578
 270 00000E 3018          SETUP1 MOVE (A0)+,D0
 280 000010 0C40FFFF       CMP #$FFFF,D0
 290 000014 6706           BEQ.S SETUP2
 300 000016 32C0           MOVE D0,(A1)+
 310 000018 22D8           MOVE.L (A0)+,(A1)+
 320 00001A 60F2           BRA SETUP1
 330 00001C B1FC00022000  SETUP2 CMP.L #$22000,A0
 340 000022 6A08           BPL.S INIT
 350 000024 207C00022082   MOVE.L #$22082,A0
 360 00002A 60E2           BRA SETUP1
 370 00002C 3280          INIT MOVE D0,(A1)
 380 00002E 207C000220D2   MOVE.L #$220D2,A0
 390 000034 303C0000       MOVE #$0000,D0
 400 000038 13C00001FFFD  INIT1 MOVE.B D0,$1FFFD
 410 00003E 1218           MOVE.B (A0)+,D1
 420 000040 4E71           NOP
 430 000042 13C10001FFFF   MOVE.B D1,$1FFFF
 440 000048 5240           ADD #1,D0
 450 00004A 0C400010       CMP #$0010,D0
 460 00004E 66E8           BNE INIT1
 470 000050 227C000229F6   MOVE.L #$229F6,A1
 480 000056 247C00001100   MOVE.L #TABLECH,A2
 490 00005C 303C0302       MOVE #770,D0
 500 000060 14D9          SETUP21 MOVE.B (A1)+,(A2)+
   0 000062 5340           SUB #1,D0
   0 000064 66FA           BNE  SETUP21
 520 000066 6014           BRA.S RETURN
 530 000068 207C00010000  CM MOVE.L #$10000,A0
 540 00006E 323C2000       MOVE #$2000,D1
 550 000072 4280          CLR.L D0
 560 000074 20C0         CLRM MOVE.L D0,(A0)+
   0 000076 5341          SUB #1,D1
   0 000078 66FA          BNE  CLRM
   0 00007A 4E71          NOP
 580 00007C 4EF9000200F6 RETURN JMP MACSBUG
 590 000082 43           NTABLE DC.W 'CM'
 600 000084 00022068      DC.L $22068
 610 000088 53            DC.W 'SH'
 620 00008A 000220E2      DC.L $220E2
 630 00008E 42            DC.W 'BX'
 640 000090 0002218A      DC.L $2218A
 650 000094 45            DC.W 'ED'
 660 000096 000221E8      DC.L $221E8
 670 00009A 42            DC.W 'BA'
 680 00009C 00022454      DC.L $22454
 690 0000A0 51            DC.W 'Q1'
 700 0000A2 00022498      DC.L $22498
 710 0000A6 51            DC.W 'Q2'
 720 0000A8 000224A4      DC.L $224A4
 730 0000AC 51            DC.W 'Q3'
 740 0000AE 000224B0      DC.L $224B0
 750 0000B2 51            DC.W 'Q4'
 760 0000B4 000224BC      DC.L $224BC
 770 0000B8 51            DC.W 'Q5'
 780 0000BA 000224C8      DC.L $224C8
 790 0000BE 51            DC.W 'Q9'
 800 0000C0 00022606      DC.L $22606
 810 0000C4 48            DC.W 'HP'
 820 0000C6 000226AC      DC.L $226AC
 830 0000CA 51            DC.W 'Q8'
 840 0000CC 00022818      DC.L $22818
 850 0000D0 FFFF          DC.W $FFFF
 860                     *
 870                     *
 880                     *
 890                     *
 900 0000D2 27           CRTC DC.B $27
 910 0000D3 20            DC.B $20
 920 0000D4 22            DC.B $22
 930 0000D5 A3            DC.B $A3
 940 0000D6 20            DC.B $20
 950 0000D7 06            DC.B $06
 960 0000D8 1F            DC.B $1F
 970 0000D9 1F            DC.B $1F
 980 0000DA 10            DC.B $10
 990 0000DB 07            DC.B 7
1000 0000DC 00000000      DC.L 0
1010 0000E0 0000          DC.W 0
1020                     *
1030                     *
1040 0000E2 61000004     SH BSR SHQ
1050 0000E6 6094          BRA RETURN
1060 0000E8 4EB900021BC2 SHQ JSR OUTPUT2
1070 0000EE 227C0003FF21  MOVE.L #$3FF21,A1
```

```
1080 0000F4 61000078     SH1 BSR INPUT
1090 0000F8 0C00000D      CMP.B #$0D,D0
1100 0000FC 6708          BEQ.S SH2
1110 0000FE 0C0000FF      CMP.B #$FF,D0
1120 000102 66F0          BNE SH1
1130 000104 6040          BRA.S SH3
1140 000106 61000066     SH2 BSR INPUT
1150 00010A 0C00000A      CMP.B #$0A,D0
1160 00010E 67F6          BEQ SH2
1170 000110 0C000000      CMP.B #0,D0
1180 000114 67F0          BEQ SH2
1190 000116 0C0000FF      CMP.B #$FF,D0
1200 00011A 672A          BEQ.S SH3
1210 00011C 4EB900021F18  JSR FIXBUF
1220 000122 2CFC4552524F  MOVE.L #'ERRO',(A6)+
1230 000128 2CFC52203B43  MOVE.L #'R ;C',(A6)+
1240 00012E 2CFC4845434B  MOVE.L #'HECK',(A6)+
1250 000134 2CFC2046494C  MOVE.L #' FIL',(A6)+
1260 00013A 2CFC45202020  MOVE.L #'E   ',(A6)+
1270 000140 4EF9000200EE  JMP MSG
1280 000146 207C00010000 SH3 MOVE.L #$10000,A0
1290 00014C 103C0055      MOVE.B #$55,D0
1300 000150 6100002A      BSR OUTPUT
1310 000154 61000018     SH4 BSR INPUT
1320 000158 1200          MOVE.B D0,D1
1330 00015A 61000012      BSR INPUT
1340 00015E E140          ASL 8,D0
1350 000160 1001          MOVE.B D1,D0
1360 000162 30C0          MOVE.W D0,(A0)+
1370 000164 B1FC00017F80  CMP.L #$17F80,A0
1380 00016A 66E8          BNE SH4
1390 00016C 4E75          RTS
1400 00016E 1011         INPUT MOVE.B (A1),D0
1410 000170 02000001      AND.B #1,D0
1420 000174 67F8          BEQ INPUT
1430 000176 10290002      MOVE.B 2(A1),D0
1440 00017A 4E75          RTS
1450 00017C 1E11         OUTPUT MOVE.B (A1),D7
1460 00017E 02070002      AND.B #2,D7
1470 000182 67F8          BEQ OUTPUT
1480 000184 13400002      MOVE.B D0,2(A1)
1490 000188 4E75          RTS
1500 00018A 4240         BX CLR D0
1510 00018C 3200          MOVE D0,D1
1520 00018E 3400          MOVE D0,D2
1530 000190 363C003F     BX3 MOVE #$3F,D3
1540 000194 207C00010000  MOVE.L #$10000,A0
1550 00019A 61000016     BX1 BSR SHOW
1560 00019E 5543          SUB #2,D3
1570 0001A0 6A02          BPL.S BX2
1580 0001A2 60EC          BRA BX3
1590 0001A4 5240         BX2 ADD #1,D0
1600 0001A6 5241          ADD #1,D1
1610 0001A8 5242          ADD #1,D2
1620 0001AA D1FC00000202  ADD.L #514,A0
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1630 0001B0 60E8            BRA BX1
1640 0001B2 3803           SHOW MOVE D3,D4
1650 0001B4 30C0           BX11 MOVE D0,(A0)+
   0 0001B6 5344            SUB #1,D4
   0 0001B8 66FA            BNE  BX11
1670 0001BA 3080            MOVE D0,(A0)
1680 0001BC 3803            MOVE D3,D4
1690 0001BE E544            ASL 2,D4
1700 0001C0 D1FC00000080 BX22 ADD.L #128,A0
1710 0001C6 3081            MOVE D1,(A0)
   0 0001C8 5344            SUB #1,D4
   0 0001CA 66F4            BNE  BX22
1730 0001CC 3803            MOVE D3,D4
1740 0001CE 3080            MOVE D0,(A0)
1750 0001D0 3100           BX33 MOVE D0,-(A0)
   0 0001D2 5344            SUB  #1,D4
   0 0001D4 66FA            BNE  BX33
1770 0001D6 3803            MOVE D3,D4
1780 0001D8 E544            ASL 2,D4
1790 0001DA 91FC00000080 BX44 SUB.L #128,A0
1800 0001E0 3082            MOVE D2,(A0)
   0 0001E2 5344            SUB  #1,D4
   0 0001E4 66F4            BNE  BX44
1820 0001E6 4E75            RTS
1830                       *
1840                       *
1850                       *
1860 0001E8 11FC00801000 ED MOVE.B #$80,X1
1870 0001EE 11FC00801001  MOVE.B #$80,Y1
1880 0001F4 11FC00001011  MOVE.B #0,NCOLOR
1890 0001FA 6100014E      ED1 BSR BLINK
1900 0001FE 61000004       BSR CMD
1910 000202 60F6           BRA ED1
1920 000204 61000230      CMD BSR READK
1930 000208 0C010020       CMP.B #$20,D1
1940 00020C 6A48           BPL.S RTS
1950 00020E 0C01000B       CMP.B #$B,D1
1960 000212 673C           BEQ.S UPARROW
1970 000214 0C01000A       CMP.B #$A,D1
1980 000218 673E           BEQ.S DWARROW
1990 00021A 0C01000C       CMP.B #$C,D1
2000 00021E 673E           BEQ.S RTARROW
2010 000220 0C010008       CMP.B #$8,D1
2020 000224 673E           BEQ.S LTARROW
2030 000226 0C010001       CMP.B #$1,D1
2040 00022A 673E           BEQ.S CMD1  CHARMODE
2050 00022C 0C010003       CMP.B #$3,D1
2060 000230 6756           BEQ.S CMD2  NCOLOR
2070 000232 0C010004       CMP.B #$4,D1
2080 000236 6738           BEQ.S CMD3
2090 000238 0C01000D       CMP.B #$0D,D1
2100 00023C 673E           BEQ.S CR
2110 00023E 0C010005       CMP.B #$5,D1
2120 000242 6732           BEQ.S CMD4
2130 000244 0C010011       CMP.B #$11,D1
```

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2140 000248 660A          BNE.S RTS1
2150 00024A 588F          ADD.L #4,A7
2160 00024C 6000FE2E      BRA RETURN
2170 000250 53381001     UPARROW SUB.B #1,Y1
2180 000254 4241         RTS1 CLR D1
2190 000256 4E75         RTS RTS
2200 000258 52381001     DWARROW ADD.B #1,Y1
2210 00025C 60F6          BRA RTS1
2220 00025E 52381000     RTARROW ADD.B #1,X1
2230 000262 60F0          BRA RTS1
2240 000264 53381000     LTARROW SUB.B #1,X1
2250 000268 60EA          BRA RTS1
2260 00026A 588F         CMD1 ADD.L #4,A7
2270 00026C 60000132      BRA CHARED
2280 000270 588F         CMD3 ADD.L #4,A7
2290 000272 600001A8      BRA DOT
2300 000276 588F         CMD4 ADD.L #4,A7
2310 000278 6000FF80      BRA ED1
2320 00027C 5E381001     CR ADD.B #7,Y1
2330 000280 11FC00001000  MOVE.B #0,X1
2340 000286 60CC          BRA RTS1
2350 000288 610001AC     CMD2 BSR READK
2360 00028C 267C00001011  MOVE.L #NCOLOR,A3
2370 000292 0C010052      CMP.B #'R',D1
2380 000296 6758          BEQ.S RED
2390 000298 0C010047      CMP.B #'G',D1
2400 00029C 6758          BEQ.S GREEN
2410 00029E 0C010042      CMP.B #'B',D1
2420 0002A2 6758          BEQ.S BLUE
2430 0002A4 0C010057      CMP.B #'W',D1
2440 0002A8 6758          BEQ.S WHITE
2450 0002AA 0C01005A      CMP.B #'Z',D1
2460 0002AE 6758          BEQ.S BLACK
2470 0002B0 0C010059      CMP.B #'Y',D1
2480 0002B4 6758          BEQ.S YELLOW
2490 0002B6 0C01004D      CMP.B #'M',D1
2500 0002BA 6758          BEQ.S MAG
2510 0002BC 0C010043      CMP.B #'C',D1
2520 0002C0 6758          BEQ.S CYAN
2530 0002C2 0C010054      CMP.B #'T',D1
2540 0002C6 6758          BEQ.S DRED
2550 0002C8 0C010048      CMP.B #'H',D1
2560 0002CC 6758          BEQ.S DGR
2570 0002CE 0C01004E      CMP.B #'N',D1
2580 0002D2 6758          BEQ.S DBLUE
2590 0002D4 0C010045      CMP.B #'E',D1
2600 0002D8 6758          BEQ.S DWH
2610 0002DA 0C010055      CMP.B #'U',D1
2620 0002DE 6758          BEQ.S DYEL
2630 0002E0 0C01002C      CMP.B #',',D1
2640 0002E4 6758          BEQ.S DMAG
2650 0002E6 0C010056      CMP.B #'V',D1
2660 0002EA 6758          BEQ.S DCYAN
2670 0002EC 4241         RTS2 CLR D1
2680 0002EE 4E75          RTS
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2690 0002F0 16BC0009      RED MOVE.B #$9,(A3)
2700 0002F4 60F6           BRA RTS2
2710 0002F6 16BC000A      GREEN MOVE.B #$A,(A3)
2720 0002FA 60F0           BRA RTS2
2730 0002FC 16BC000C      BLUE MOVE.B #$C,(A3)
2740 000300 60EA           BRA RTS2
2750 000302 16BC000F      WHITE MOVE.B #$F,(A3)
2760 000306 60E4           BRA RTS2
2770 000308 16BC0000      BLACK MOVE.B #0,(A3)
2780 00030C 60DE           BRA RTS2
2790 00030E 16BC000B      YELLOW MOVE.B #$B,(A3)
2800 000312 60D8           BRA RTS2
2810 000314 16BC000D      MAG MOVE.B #$D,(A3)
2820 000318 60D2           BRA RTS2
2830 00031A 16BC000E      CYAN MOVE.B #$E,(A3)
2840 00031E 60CC           BRA RTS2
2850 000320 16BC0001      DRED MOVE.B #1,(A3)
2860 000324 60C6           BRA RTS2
2870 000326 16BC0002      DGR MOVE.B #2,(A3)
2880 00032A 60C0           BRA RTS2
2890 00032C 16BC0004      DBLUE MOVE.B #4,(A3)
2900 000330 60BA           BRA RTS2
2910 000332 16BC0007      DWH MOVE.B #7,(A3)
2920 000336 60B4           BRA RTS2
2930 000338 16BC0003      DYEL MOVE.B #3,(A3)
2940 00033C 60AE           BRA RTS2
2950 00033E 16BC0005      DMAG MOVE.B #5,(A3)
2960 000342 60A8           BRA RTS2
2970 000344 16BC0006      DCYAN MOVE.B #6,(A3)
2980 000348 60A2           BRA RTS2
2990                      *
3000 00034A 12381000      BLINK MOVE.B X1,D1
3010 00034E 14381001       MOVE.B Y1,D2
3020 000352 61000226       BSR GETADD
3030 000356 4643           NOT D3
3040 000358 0C03000F      BL2 CMP.B #$F,D3
3050 00035C 6706           BEQ.S BL1
3060 00035E E84B           LSR 4,D3
3070 000360 E849           LSR 4,D1
3080 000362 60F4           BRA BL2
3090 000364 11C11012      BL1 MOVE.B D1,OCOLOR
3100 000368 103C000F      BL3 MOVE.B #$F,D0
3110 00036C 12381000       MOVE.B X1,D1
3120 000370 14381001       MOVE.B Y1,D2
3130 000374 610001DE       BSR DSP
3140 000378 610000D0       BSR DLY
3150 00037C 4200           CLR.B D0
3160 00037E 610001D4       BSR DSP
3170 000382 610000C6       BSR DLY
3180 000386 10381012       MOVE.B OCOLOR,D0
3190 00038A 610001C8       BSR DSP
3200 00038E 610000BA       BSR DLY
3210 000392 10390003FF01   MOVE.B $3FF01,D0
3220 000398 02000001       AND.B #1,D0
3230 00039C 67CA           BEQ BL3
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3240 00039E 4E75          RTS
3250                     *
3260 0003A0 31F810001002 CHARED MOVE X1,X2
3270 0003A6 61A2          BSR BLINK
3280 0003A8 6100FE5A      BSR CMD
3290 0003AC 4A01          TST.B D1
3300 0003AE 67F0          BEQ CHARED
3310 0003B0 61000004      BSR CHAR
3320 0003B4 60EA          BRA CHARED
3330 0003B6 04010020     CHAR SUB.B #$20,D1
3340 0003BA E741          ASL 3,D1
3350 0003BC 267C00001100  MOVE.L #TABLECH,A3
3360 0003C2 0281000003FF  AND.L #$3FF,D1
3370 0003C8 D7C1          ADD.L D1,A3
3380 0003CA 3C3C0004      MOVE #4,D6
3390 0003CE 4245         CHARED1 CLR D5
3400 0003D0 0B13         CHARED2 BTST D5,(A3)
3410 0003D2 6636          BNE.S SET
3420 0003D4 52381002     CHARED3 ADD.B #1,X2
3430 0003D8 5245          ADD #1,D5
3440 0003DA 0C450010      CMP #16,D5
3450 0003DE 6618          BNE.S CHARED4
3460 0003E0 52381003      ADD.B #1,Y2
3470 0003E4 11F810001002  MOVE.B X1,X2
3480 0003EA D7F80002      ADD.L $2,A3
   0 0003EE 5346          SUB  #1,D6
   0 0003F0 66DC          BNE  CHARED1
3500 0003F2 50381000      ADD.B #8,X1
3510 0003F6 4E75          RTS
3520 0003F8 0C450008     CHARED4 CMP #8,D5
3530 0003FC 66D2          BNE CHARED2
3540 0003FE 52381003      ADD.B #1,Y2
3550 000402 11F810001002  MOVE.B X1,X2
3560 000408 60C6          BRA CHARED2
3570 00040A 10381011     SET MOVE.B NCOLOR,D0
3580 00040E 12381002      MOVE.B X2,D1
3590 000412 14381003      MOVE.B Y2,D2
3600 000416 6100013C      BSR DSP
3610 00041A 60B8          BRA CHARED3
3620                     *
3630 00041C 10381011     DOT MOVE.B NCOLOR,D0
3640 000420 12381000      MOVE.B X1,D1
3650 000424 14381001      MOVE.B Y1,D2
3660 000428 6100012A      BSR DSP
3670 00042C 6100FF1C      BSR BLINK
3680 000430 6100FDD2      BSR CMD
3690 000434 60E6          BRA DOT
3700                     *
3710 000436 123900003FF01 READK MOVE.B $3FF01,D1
3720 00043C 02010001      AND.B #1,D1
3730 000440 67F4          BEQ READK
3740 000442 123900003FF03  MOVE.B $3FF03,D1
3750 000448 4E75          RTS
3760 00044A 3C3C00FF     DLY MOVE #$00FF,D6
3770 00044E 5346         DLY1 SUB #1,D6
```

```
3780 000450 66FC            BNE DLY1
3790 000452 4E75            RTS
3800                       *
3810                       *
3820                       *
3830 000454 207C00010000 BA MOVE.L #$10000,A0
3840 00045A 227C0003FF23  MOVE.L #$3FF23,A1
3850 000460 247C0003FF21  MOVE.L #$3FF21,A2
3860 000466 1212         L1 MOVE.B (A2),D1
3870 000468 02010002      AND.B #$2,D1
3880 00046C 67F8          BEQ L1
3890 00046E 103C0065      MOVE.B #$65,D0
3900 000472 1280          MOVE.B D0,(A1)
3910 000474 1212         LOOP MOVE.B (A2),D1
3920 000476 02010002      AND.B #$2,D1
3930 00047A 67F8          BEQ LOOP
3940 00047C 3018          MOVE (A0)+,D0
3950 00047E 1280          MOVE.B D0,(A1)
3960 000480 E048          LSR 8,D0
3970 000482 1212         L2 MOVE.B (A2),D1
3980 000484 02010002      AND.B #$2,D1
3990 000488 67F8          BEQ L2
4000 00048A 1280          MOVE.B D0,(A1)
4010 00048C B1FC00018000  CMP.L #$18000,A0
4020 000492 66E0          BNE LOOP
4030 000494 6000FBE6      BRA RETURN
4040                     *
4050                     *
4060                     *
4070 000498 2C7C000225AC Q1 MOVE.L #$225AC,A6
4080 00049E 3E3C0010      MOVE #$10,D7
4090 0004A2 602E          BRA.S RUN
4100 0004A4 2C7C000225BE Q2 MOVE.L #$225BE,A6
4110 0004AA 3E3C0010      MOVE #$10,D7
4120 0004AE 6022          BRA.S RUN
4130 0004B0 2C7C000225D0 Q3 MOVE.L #$225D0,A6
4140 0004B6 3E3C0010      MOVE #$10,D7
4150 0004BA 6016          BRA.S RUN
4160 0004BC 2C7C000225E2 Q4 MOVE.L #$225E2,A6
4170 0004C2 3E3C0010      MOVE #$10,D7
4180 0004C6 600A          BRA.S RUN
4190 0004C8 2C7C000225F4 Q5 MOVE.L #$225F4,A6
4200 0004CE 3E3C0010      MOVE #$10,D7
4210 0004D2 61000006     RUN BSR RUN1
4220 0004D6 6000FBA4      BRA RETURN
4230                     *
4240                     *
4250                     *
4260 0004DA 3C3C0080     RUN1 MOVE #128,D6
4270 0004DE 61000034      BSR RAND
4280 0004E2 4E96         RUN2 JSR (A6)
4290 0004E4 48E76000      MOVEM.L D1/D2,-(A7)
4300 0004E8 0241007F      AND #$7F,D1
4310 0004EC 0242007F      AND #$7F,D2
4320 0004F0 61000068      BSR DSPLY
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4330 0004F4 4401           NEG.B D1
4340 0004F6 61000062       BSR DSPLY
4350 0004FA 4402           NEG.B D2
4360 0004FC 6100005C       BSR DSPLY
4370 000500 4401           NEG.B D1
4380 000502 61000056       BSR DSPLY
4390 000506 4CDF0006       MOVEM.L (A7)+,D1/D2
   0 00050A 5346           SUB  #1,D6
   0 00050C 66D4           BNE  RUN2
   0 00050E 5347           SUB  #1,D7
   0 000510 66C8           BNE  RUN1
4420 000512 4E75           RTS
4430                      *
4440                      *
4450                      *
4460 000514 6100001C      RAND BSR RAND1
4470 000518 3200           MOVE D0,D1
4480 00051A 61000016       BSR RAND1
4490 00051E 3400           MOVE D0,D2
4500 000520 61000010      RAND2 BSR RAND1
4510 000524 0200000F       AND.B #$F,D0
4520 000528 67F6           BEQ RAND2
4530 00052A 0C000008       CMP.B #$08,D0
4540 00052E 67F0           BEQ RAND2
4550 000530 4E75           RTS
4560 000532 10381019      RAND1 MOVE.B RANADD+1,D0
4570 000536 E500           ASL.B 2,D0
4580 000538 D0381018       ADD.B RANADD,D0
4590 00053C E140           ASL 8,D0
4600 00053E 10381019       MOVE.B RANADD+1,D0
4610 000542 E540           ASL 2,D0
4620 000544 D0781018       ADD RANADD,D0
4630 000548 06403619       ADD #$3619,D0
4640 00054C 31C01018       MOVE D0,RANADD
4650 000550 E048           LSR 8,D0
4660 000552 4E75           RTS
4670                      *
4680                      *
4690                      *
4700                      *DSPLY(C,X,Y)
4710                      *  D0=COLOR
4720                      *  D1=X 8-BITS
4730                      *  D2=Y 8-BITS
4740                      *
4750 000554 48E7F080      DSP MOVEM.L D0-D3/A0,-(A7)
4760 000558 600C           BRA.S DSP1
4770                      *
4780 00055A 48E7F080      DSPLY MOVEM.L D0-D3/A0,-(A7)
4790 00055E 06010080       ADD.B #128,D1
4800 000562 06020080       ADD.B #128,D2
4810 000566 0240000F      DSP1 AND #$F,D0
4820 00056A 6100000E       BSR GETADD
4830 00056E C243           AND D3,D1
4840 000570 8041           OR D1,D0
4850 000572 3080           MOVE D0,(A0)
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4860 000574 4CDF010F       MOVEM.L (A7)+,D0-D3/A0
4870 000578 4E75           RTS
4880 00057A 024100FF      GETADD AND #$FF,D1
4890 00057E 363CFFF0       MOVE #$FFF0,D3
4900 000582 E142           ASL 8,D2
4910 000584 D242           ADD D2,D1
4920 000586 02810000FFFF   AND.L #$FFFF,D1
4930 00058C 3401           MOVE D1,D2
4940 00058E E449           LSR 2,D1
4950 000590 E341           ASL 1,D1
4960 000592 207C00010000   MOVE.L #$10000,A0
4970 000598 D1C1           ADD.L D1,A0
4980 00059A 02420003       AND #3,D2
4990 00059E 6708           BEQ.S DSPLY1
5000 0005A0 E940          DSPLY2 ASL 4,D0
5010 0005A2 E95B           ROL 4,D3
   0 0005A4 5342           SUB  #1,D2
   0 0005A6 66F8           BNE  DSPLY2
5030 0005A8 3210          DSPLY1 MOVE (A0),D1
5040 0005AA 4E75           RTS
5050                      *
5060                      *
5070 0005AC 3601          EQU1 MOVE D1,D3
5080 0005AE 3802           MOVE D2,D4
5090 0005B0 4883           EXT D3
5100 0005B2 4884           EXT D4
5110 0005B4 E64B           LSR 3,D3
5120 0005B6 E64C           LSR 3,D4
5130 0005B8 9403           SUB.B D3,D2
5140 0005BA 9204           SUB.B D4,D1
5150 0005BC 4E75           RTS
5160                      *
5170 0005BE 3602          EQU2 MOVE D2,D3
5180 0005C0 4883           EXT D3
5190 0005C2 E64B           LSR 3,D3
5200 0005C4 9203           SUB.B D3,D1
5210 0005C6 3801           MOVE D1,D4
5220 0005C8 4884           EXT D4
5230 0005CA E64C           LSR 3,D4
5240 0005CC D404           ADD.B D4,D2
5250 0005CE 4E75           RTS
5260                      *
5270                      *
5280 0005D0 3602          EQU3 MOVE D2,D3
5290 0005D2 4883           EXT D3
5300 0005D4 E24B           LSR 1,D3
5310 0005D6 D203           ADD.B D3,D1
5320 0005D8 3801           MOVE D1,D4
5330 0005DA 4884           EXT D4
5340 0005DC E24C           LSR 1,D4
5350 0005DE 9404           SUB.B D4,D2
5360 0005E0 4E75           RTS
5370                      *
5380 0005E2 3602          EQU4 MOVE D2,D3
5390 0005E4 4883           EXT D3
```

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5400 0005E6 E64B          LSR 3,D3
5410 0005E8 9203          SUB.B D3,D1
5420 0005EA 3801          MOVE D1,D4
5430 0005EC 4884          EXT D4
5440 0005EE E64C          LSR 3,D4
5450 0005F0 9404          SUB.B D4,D2
5460 0005F2 4E75          RTS
5470                     *
5480 0005F4 3602         EQU5 MOVE D2,D3
5490 0005F6 4883          EXT D3
5500 0005F8 E24B          LSR 1,D3
5510 0005FA 9203          SUB.B D3,D1
5520 0005FC 3801          MOVE D1,D4
5530 0005FE 4884          EXT D4
5540 000600 E44C          LSR 2,D4
5550 000602 D404          ADD.B D4,D2
5560 000604 4E75          RTS
5570 000606 2C7C000225AC Q9 MOVE.L #$225AC,A6
5580 00060C 3A3C0002     Q91 MOVE #2,D5
5590 000610 61000044     Q92 BSR CMQ
5600 000614 3E3C0020      MOVE #$20,D7
5610 000618 6100FEC0      BSR RUN1
5620 00061C 6100002C      BSR DLYQ
5630 000620 48E70402      MOVEM.L D5/A6,-(A7)
5640 000624 6100008E      BSR HP1
5650 000628 4CDF4020      MOVEM.L (A7)+,D5/A6
5660 00062C 6100001C      BSR DLYQ
   0 000630 5345          SUB  #1,D5
   0 000632 66DC          BNE  Q92
5680 000634 61000034      BSR LOGO
5690 000638 DDFC00000012  ADD.L #$12,A6
5700 00063E BDFC00022606  CMP.L #$22606,A6
5710 000644 670001D2      BEQ Q8
5720 000648 60C2          BRA Q91
5730 00064A 283C000AFFFF DLYQ MOVE.L #$000AFFFF,D4
5740 000650 5384         DLYQ1 SUB.L #1,D4
5750 000652 66FC          BNE DLYQ1
5760 000654 4E75          RTS
5770 000656 4280         CMQ CLR.L D0
5780 000658 323C2000      MOVE #$2000,D1
5790 00065C 207C00010000  MOVE.L #$10000,A0
5800 000662 20C0         CMQ1 MOVE.L D0,(A0)+
   0 000664 5341          SUB  #1,D1
   0 000666 66FA          BNE  CMQ1
5820 000668 4E75          RTS
5830 00066A 48E7FFFE     LOGO MOVEM.L D0-D7/A0-A6,-(A7)
5840 00066E 4EB900021F18  JSR FIXBUF
5850 000674 2CFC53482053  MOVE.L #'SH S',(A6)+
5860 00067A 2CFC4C494445  MOVE.L #'LIDE',(A6)+
5870 000680 1CBC0020      MOVE.B #' ',(A6)
5880 000684 6100FA62      BSR SHQ
5890 000688 61C0          BSR DLYQ
5900 00068A 4EB900021F18  JSR FIXBUF
5910 000690 2CFC5348204D  MOVE.L #'SH M',(A6)+
5920 000696 2CFC41534B20  MOVE.L #'ASK ',(A6)+
5930 00069C 6100FA4A       BSR SHQ
5940 0006A0 4CDF7FFF       MOVEM.L (A7)+,D0-D7/A0-A6
5950 0006A4 283C0010FFFF   MOVE.L #$0010FFFF,D4
5960 0006AA 60A4           BRA DLYQ1
5970                       *
5980 0006AC 61000006      HP BSR HP1
5990 0006B0 6000F9CA       BRA RETURN
6000 0006B4 267C00001080  HP1 MOVE.L #ARRAY,A3
6010 0006BA 619A           BSR CMQ
6020 0006BC 4241           CLR D1
6030 0006BE 4242           CLR D2
6040 0006C0 363C00FF       MOVE #$FF,D3
6050 0006C4 3803           MOVE D3,D4
6060 0006C6 6100FE6A       BSR RAND1
6070 0006CA 02000007       AND.B #7,D0
6080 0006CE 5A00           ADD.B #5,D0
6090 0006D0 E340           ASL 1,D0
6100 0006D2 11C01014       MOVE.B D0,NUMPT
6110 0006D6 6100FE5A       BSR RAND1
6120 0006DA 0200001F       AND.B #$1F,D0
6130 0006DE 00000005       OR.B #$5,D0
6140 0006E2 11C01016       MOVE.B D0,SCALE
6150 0006E6 4245           CLR D5
6160 0006E8 6100FE48      H6 BSR RAND1
6170 0006EC 024000FF       AND #$FF,D0
6180 0006F0 17805000       MOVE.B D0,0(A3,D5)
6190 0006F4 B240           CMP D0,D1
6200 0006F6 6A02           BPL.S H1
6210 0006F8 1200           MOVE.B D0,D1
6220 0006FA B640          H1 CMP D0,D3
6230 0006FC 6B02           BMI.S H2
6240 0006FE 1600           MOVE.B D0,D3
6250 000700 6100FE30      H2 BSR RAND1
6260 000704 024000FF       AND #$FF,D0
6270 000708 17805001       MOVE.B D0,1(A3,D5)
6280 00070C B440           CMP D0,D2
6290 00070E 6A02           BPL.S H3
6300 000710 1400           MOVE.B D0,D2
6310 000712 B840          H3 CMP D0,D4
6320 000714 6B02           BMI.S H4
6330 000716 1800           MOVE.B D0,D4
6340 000718 BA381014      H4 CMP.B NUMPT,D5
6350 00071C 6704           BEQ.S H5
6360 00071E 5405           ADD.B #2,D5
6370 000720 60C6           BRA H6
6380        00000722      H5 EQU *
6390 000722 9203          H8 SUB.B D3,D1
6400 000724 9404           SUB.B D4,D2
6410 000726 4245           CLR D5
6420 000728 97335000      H61 SUB.B D3,0(A3,D5)
6430 00072C 99335001       SUB.B D4,1(A3,D5)
6440 000730 BA381014       CMP.B NUMPT,D5
6450 000734 6704           BEQ.S H9
6460 000736 5405           ADD.B #2,D5
6470 000738 60EE           BRA H61
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6480 00073A 4243           H9 CLR D3
6490 00073C 203C0000FF00    MOVE.L #$FF00,D0
6500 000742 024100FF        AND #$FF,D1
6510 000746 80C1            DIVU D1,D0
6520 000748 4245            CLR D5
6530 00074A 16335000       H12 MOVE.B 0(A3,D5),D3
6540 00074E C6C0            MULU D0,D3
6550 000750 E04B            LSR 8,D3
6560 000752 17835000        MOVE.B D3,0(A3,D5)
6570 000756 BA381014        CMP.B NUMPT,D5
6580 00075A 6704            BEQ.S H11
6590 00075C 5405            ADD.B #2,D5
6600 00075E 60EA            BRA H12
6610 000760 203C0000FF00 H11 MOVE.L #$FF00,D0
6620 000766 024200FF        AND #$FF,D2
6630 00076A 80C2            DIVU D2,D0
6640 00076C 4245            CLR D5
6650 00076E 16335001       H14 MOVE.B 1(A3,D5),D3
6660 000772 C6C0            MULU D0,D3
6670 000774 E04B            LSR 8,D3
6680 000776 17835001        MOVE.B D3,1(A3,D5)
6690 00077A BA381014        CMP.B NUMPT,D5
6700 00077E 6704            BEQ.S H13
6710 000780 5405            ADD.B #2,D5
6720 000782 60EA            BRA H14
6730 000784 31D31000       H13 MOVE (A3),X1
6740 000788 3E3C001C       H131 MOVE #$1C,D7
6750 00078C 54381014       H132 ADD.B #2,NUMPT
6760 000790 1A381014        MOVE.B NUMPT,D5
6770 000794 37935000        MOVE (A3),0(A3,D5)
6780 000798 3C3C0004       H15 MOVE #4,D6
6790 00079C 6100FD94        BSR RAND1
6800 0007A0 0240000F        AND #$F,D0
6810 0007A4 67F2            BEQ H15
6820 0007A6 0C000008        CMP.B #$8,D0
6830 0007AA 67EC            BEQ H15
6840 0007AC 0C00000F        CMP.B #$F,D0
6850 0007B0 67E6            BEQ H15
6860 0007B2 4245           HP6 CLR D5
6870 0007B4 12335000       H17 MOVE.B 0(A3,D5),D1
6880 0007B8 14335001        MOVE.B 1(A3,D5),D2
6890 0007BC 6100008A       HP17 BSR LINE
6900 0007C0 BA381014        CMP.B NUMPT,D5
6910 0007C4 6748            BEQ.S H16
6920 0007C6 12335002        MOVE.B 2(A3,D5),D1
6930 0007CA 14335000        MOVE.B 0(A3,D5),D2
6940 0007CE 024100FF        AND #$FF,D1
6950 0007D2 024200FF        AND #$FF,D2
6960 0007D6 9242            SUB D2,D1
6970 0007D8 16381016        MOVE.B SCALE,D3
6980 0007DC 024300FF        AND #$FF,D3
6990 0007E0 C3C3            MULS D3,D1
7000 0007E2 E049            LSR 8,D1
7010 0007E4 D3335000        ADD.B D1,0(A3,D5)
7020 0007E8 12335003        MOVE.B 3(A3,D5),D1
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7030 0007EC 024100FF      AND #$FF,D1
7040 0007F0 14335001      MOVE.B 1(A3,D5),D2
7050 0007F4 024200FF      AND #$FF,D2
7060 0007F8 9242          SUB D2,D1
7070 0007FA 16381016      MOVE.B SCALE,D3
7080 0007FE 024300FF      AND #$FF,D3
7090 000802 C3C3          MULS D3,D1
7100 000804 E049          LSR 8,D1
7110 000806 D3335001      ADD.B D1,1(A3,D5)
7120 00080A 5445          ADD #2,D5
7130 00080C 60A6          BRA H17
7140 00080E 5346         H16 SUB #1,D6
7150 000810 66A0          BNE HP6
7160 000812 5347          SUB #1,D7
7170 000814 6682          BNE H15
7180 000816 4E75          RTS
7190 000818 6100FE9A     Q8 BSR HP1
7200 00081C 283C000AFFFF  MOVE.L #$AFFFF,D4
7210 000822 6100FE2C      BSR DLYQ1
7220 000826 60F0          BRA Q8
7230                     *
7240                     *
7250                     *
7260 000828 12290002     DXDY MOVE.B 2(A1),D1
7270 00082C 9211          SUB.B (A1),D1
7280 00082E 650A          BCS.S XNEG
7290 000830 13410004      MOVE.B D1,4(A1)
7300 000834 42290006      CLR.B 6(A1)
7310 000838 4E75          RTS
7320 00083A 137C00010006 XNEG MOVE.B #1,6(A1)
7330 000840 4401          NEG.B D1
7340 000842 13410004      MOVE.B D1,4(A1)
7350 000846 4E75          RTS
7360                     *
7370                     *
7380        00000848     LINE EQU *
7390 000848 48E7FFFE     DRAW MOVEM.L D0-D7/A0-A6,-(A7)
7400 00084C 227C00001000  MOVE.L #X1,A1
7410 000852 13410002      MOVE.B D1,2(A1)
7420 000856 13420003      MOVE.B D2,3(A1)
7430 00085A 1211          MOVE.B (A1),D1
7440 00085C 14290001      MOVE.B 1(A1),D2
7450 000860 6100FCF2      BSR DSP
7460 000864 61C2         DRAW1 BSR DXDY
7470 000866 5289          ADD.L #1,A1
7480 000868 61BE          BSR DXDY
7490 00086A 5389          SUB.L #1,A1
7500 00086C 1211          MOVE.B (A1),D1
7510 00086E 14290001      MOVE.B 1(A1),D2
7520 000872 4A290004      TST.B 4(A1)
7530 000876 6766          BEQ.S DXZ
7540 000878 4A290005      TST.B 5(A1)
7550 00087C 67000088      BEQ DYZ
7560 000880 16290004      MOVE.B 4(A1),D3
7570 000884 B6290005      CMP.B 5(A1),D3
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7580 000888 660000B0       BNE FULMOV
7590 00088C 4A290006       TST.B 6(A1)
7600 000890 6626           BNE.S SXN
7610 000892 4A290007       TST.B 7(A1)
7620 000896 6636           BNE.S SYN
7630 000898 6100FCBA      XPYP1 BSR DSP
7640 00089C 5201           ADD.B #1,D1
7650 00089E 5202           ADD.B #1,D2
7660 0008A0 B2290002       CMP.B 2(A1),D1
7670 0008A4 66F2           BNE XPYP1
7680 0008A6 607E           BRA.S XYDONE
7690 0008A8 6100FCAA      SXNSYN BSR DSP
7700 0008AC 5301           SUB.B #1,D1
7710 0008AE 5302           SUB.B #1,D2
7720 0008B0 B2290002       CMP.B 2(A1),D1
7730 0008B4 66F2           BNE SXNSYN
7740 0008B6 606E           BRA.S XYDONE
7750 0008B8 4A290007      SXN TST.B 7(A1)
7760 0008BC 66EA           BNE.S SXNSYN
7770 0008BE 6100FC94      SNP BSR DSP
7780 0008C2 5301           SUB.B #1,D1
7790 0008C4 5202           ADD.B #1,D2
7800 0008C6 B2290002       CMP.B 2(A1),D1
7810 0008CA 66F2           BNE SNP
7820 0008CC 6058           BRA.S XYDONE
7830 0008CE 6100FC84      SYN BSR DSP
7840 0008D2 5201           ADD.B #1,D1
7850 0008D4 5302           SUB.B #1,D2
7860 0008D6 B2290002       CMP.B 2(A1),D1
7870 0008DA 66F2           BNE SYN
7880 0008DC 6048           BRA.S XYDONE
7890 0008DE 4A290005      DXZ TST.B 5(A1)
7900 0008E2 6742           BEQ.S XYDONE
7910 0008E4 4A290007       TST.B 7(A1)
7920 0008E8 660E           BNE.S DXZYN
7930 0008EA 6100FC68      DXZ1 BSR DSP
7940 0008EE 5202           ADD.B #1,D2
7950 0008F0 B4290003       CMP.B 3(A1),D2
7960 0008F4 66F4           BNE DXZ1
7970 0008F6 602E           BRA.S XYDONE
7980 0008F8 6100FC5A      DXZYN BSR DSP
7990 0008FC 5302           SUB.B #1,D2
8000 0008FE B4290003       CMP.B 3(A1),D2
8010 000902 66F4           BNE DXZYN
8020 000904 6020           BRA.S XYDONE
8030 000906 4A290006      DYZ TST.B 6(A1)
8040 00090A 660E           BNE.S DYZN
8050 00090C 6100FC46      DYZ1 BSR DSP
8060 000910 5201           ADD.B #1,D1
8070 000912 B2290002       CMP.B 2(A1),D1
8080 000916 66F4           BNE DYZ1
8090 000918 600C           BRA.S XYDONE
8100 00091A 6100FC38      DYZN BSR DSP
8110 00091E 5301           SUB.B #1,D1
8120 000920 B2290002       CMP.B 2(A1),D1
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8130 000924 66F4          BNE DYZN
8140 000926 32A90002     XYDONE MOVE 2(A1),(A1)
8150 00092A 1211          MOVE.B (A1),D1
8160 00092C 14290001      MOVE.B 1(A1),D2
8170 000930 6100FC22      BSR DSP
8180 000934 4CDF7FFF      MOVEM.L (A7)+,D0-D7/A0-A6
8190 000938 4E75          RTS
8200 00093A 33510008     FULMOV MOVE (A1),8(A1)
8210 00093E 16290004      MOVE.B 4(A1),D3
8220 000942 96290005      SUB.B 5(A1),D3
8230 000946 6208          BHI.S FUL1
8240 000948 337C0001000A  MOVE #$1,10(A1)
8250 00094E 6046          BRA.S FUL4
8260 000950 337C0100000A FUL1 MOVE #$100,10(A1)
8270 000956 603E          BRA.S FUL4
8280 000958 16290008     FUL2 MOVE.B 8(A1),D3
8290 00095C 9611          SUB.B (A1),D3
8300 00095E 6402          BCC.S FUL21
8310 000960 4403          NEG.B D3
8320 000962 024300FF     FUL21 AND #$FF,D3
8330 000966 18290005      MOVE.B 5(A1),D4
8340 00096A 024400FF      AND #$FF,D4
8350 00096E C6C4          MULU D4,D3
8360 000970 18290009      MOVE.B 9(A1),D4
8370 000974 98290001      SUB.B 1(A1),D4
8380 000978 6402          BCC.S FUL22
8390 00097A 4404          NEG.B D4
8400 00097C 1A290004     FUL22 MOVE.B 4(A1),D5
8410 000980 024400FF      AND #$FF,D4
8420 000984 024500FF      AND #$FF,D5
8430 000988 C8C5          MULU D5,D4
8440 00098A 4A29000A      TST.B 10(A1)
8450 00098E 660E          BNE.S FULY
8460 000990 B883          CMP.L D3,D4
8470 000992 6710          BEQ.S GREAT
8480 000994 620E          BHI.S GREAT
8490 000996 3369000A000E FUL4 MOVE 10(A1),14(A1)
8500 00099C 600C          BRA.S SAME
8510 00099E B883         FULY CMP.L D3,D4
8520 0009A0 6702          BEQ.S GREAT
8530 0009A2 62F2          BHI.S FUL4
8540 0009A4 337C0101000E GREAT MOVE #$0101,14(A1)
8550 0009AA 12290008     SAME MOVE.B 8(A1),D1
8560 0009AE 14290009      MOVE.B 9(A1),D2
8570 0009B2 4A290007      TST.B 7(A1)
8580 0009B6 6606          BNE.S NEGY
8590 0009B8 D429000F      ADD.B 15(A1),D2
8600 0009BC 6004          BRA.S S2
8610 0009BE 9429000F     NEGY SUB.B 15(A1),D2
8620 0009C2 13420009     S2 MOVE.B D2,9(A1)
8630 0009C6 4A290006      TST.B 6(A1)
8640 0009CA 6606          BNE.S NEGX
8650 0009CC D229000E      ADD.B 14(A1),D1
8660 0009D0 6004          BRA.S S3
8670 0009D2 9229000E     NEGX SUB.B 14(A1),D1
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8680 0009D6 13410008       S3 MOVE.B D1,8(A1)
8690 0009DA 6100FB78       FUL3 BSR DSP
8700 0009DE B2290002        CMP.B 2(A1),D1
8710 0009E2 670A            BEQ.S DRAW2
8720 0009E4 B4290003        CMP.B 3(A1),D2
8730 0009E8 6704            BEQ.S DRAW2
8740 0009EA 6000FF6C        BRA FUL2
8750 0009EE 32A90008       DRAW2 MOVE 8(A1),(A1)
8760 0009F2 6000FE70        BRA DRAW1
8770 0009F6 0000            END

 ****** TOTAL ERRORS   0--   0


 SYMBOL TABLE

 ARRAY      001080 BA         000454 BL1        000364 BL2        000358
 BL3        000368 BLACK      000308 BLINK      00034A BLUE       0002FC
 BX         00018A BX1        00019A BX11       0001B4 BX2        0001A4
 BX22       0001C0 BX3        000190 BX33       0001D0 BX44       0001DA
 CHAR       0003B6 CHARED     0003A0 CHARED1    0003CE CHARED2    0003D0
 CHARED3    0003D4 CHARED4    0003F8 CHTAB      0009F6 CLRM       000074
 CM         000068 CMD        000204 CMD1       00026A CMD2       000288
 CMD3       000270 CMD4       000276 CMDTAB     001800 CMQ        000656
 CMQ1       000662 COLOR      001010 CR         00027C CRTC       0000D2
 CYAN       00031A DBLUE      00032C DCYAN      000344 DGR        000326
 DLY        00044A DLY1       00044E DLYQ       00064A DLYQ1      000650
 DMAG       00033E DOT        00041C DRAW       000848 DRAW1      000864
 DRAW2      0009EE DRED       000320 DSP        000554 DSP1       000566
 DSPLY      00055A DSPLY1     0005A8 DSPLY2     0005A0 DWARROW    000258
 DWH        000332 DXDY       000828 DXZ        0008DE DXZ1       0008EA
 DXZYN      0008F8 DYEL       000338 DYZ        000906 DYZ1       00090C
 DYZN       00091A ED         0001E8 ED1        0001FA EQU1       0005AC
 EQU2       0005BE EQU3       0005D0 EQU4       0005E2 EQU5       0005F4
 FIXBUF     021F18 FUL1       000950 FUL2       000958 FUL21      000962
 FUL22      00097C FUL3       0009DA FUL4       000996 FULMOV     00093A
 FULY       00099E GETADD     00057A GREAT      0009A4 GREEN      0002F6
 H1         0006FA H11        000760 H12        00074A H13        000784
 H131       000788 H132       00078C H14        00076E H15        000798
 H16        00080E H17        0007B4 H2         000700 H3         000712
 H4         000718 H5         000722 H6         0006E8 H61        000728
 H8         000722 H9         00073A HP         0006AC HP1        0006B4
 HP17       0007BC HP6        0007B2 INIT       00002C INIT1      000038
 INPUT      00016E L1         000466 L2         000482 LINE       000848
 LOGO       00066A LOOP       000474 LTARROW    000264 MACSBUG    0200F6
 MAG        000314 MSG        0200EE NCOLOR     001011 NEGX       0009D2
 NEGY       0009BE NTABLE     000082 NUMPT      001014 OCOLOR     001012
 OUTPUT     00017C OUTPUT2    021BC2 Q1         000498 Q2         0004A4
 Q3         0004B0 Q4         0004BC Q5         0004C8 Q8         000818
 Q9         000606 Q91        00060C Q92        000610 RANADD     001018
 RAND       000514 RAND1      000532 RAND2      000520 READK      000436
 RED        0002F0 RETURN     00007C RTARROW    00025E RTS        000256
 RTS1       000254 RTS2       0002EC RUN        0004D2 RUN1       0004DA
 RUN2       0004E2 S2         0009C2 S3         0009D6 SAME       0009AA
 SCALE      001016 SET        00040A SETUP      000000 SETUP1     00000E
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SETUP2     00001C SETUP21    000060 SH         0000E2 SH1        0000F4
SH2        000106 SH3        000146 SH4        000154 SHOW       0001B2
SHQ        0000E8 SNP        0008BE SXN        0008B8 SXNSYN     0008A8
SYN        0008CE TABLECH    001100 UPARROW    000250 WHITE      000302
X1         001000 X2         001002 XNEG       00083A XPYP1      000898
XYDONE     000926 Y1         001001 Y2         001003 YELLOW     00030E
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